BIODIVERSITY OF LAKE VICTORIA:

ITS CONSERVATION AND SUSTAINABLE USE

[THE UGANDAN VERSION]

Edited By:
Ogutu-Ohwayo, R. and Ndawula L.
National Agricultural Research Organisation,
Fisheries Resources Research Institute,
P. O. Box 343, Jinja, Uganda

December 2000

CHAPTER 14

The role of nearshore areas and other refugia in survival of fishes especially haplochromines in Lake Victoria, with specific reference to Napoleon Gulf

Introduction

Before introduction and establishment of the Nile perch *Lales nilolicus*, haplochromines were the most abundance group of fishes in Lake Victoria, Kyoga and Nabugabo. They formed at least 83%, by weight of the fish biomass in Lake Victoria up to early 1980s (Kudhongania & Cordone 1974, Okaronon *el ai*, 1985). They occupied virtually all trophic levels and played an important role in the flow of organic matter in these ecosystems. Each species had its own unique combination of food and habitat preference (van Oijen 1982, Goldschmidt *et al 1990).* Up to eleven trophic groups were identified in the Mwanza Gulf van Oijen op. cit.). These included; phytoplanktivores, detritivores, algal grazers, plant eaters, molluscivores, parasite eaters, zooplanktivores, insectivores, piscivores, paedophages, and scale eaters. The detritivorousl phytoplanktivores and the pelagic phytoplanktivores together constituted about 50% of the total haplochromine biomass in the lake (Goldschmidt 1986, Witte & van Oijen 1990).

By 1990, haplochromines comprised less than 2% of the biomass, (Ogutu-Ohwayo, 1990; Witte *el al.,* 1992). During trawl surveys of 1993/95 in the Ugandan offshore waters of Lake Victoria, haplochromines comprised 0.2% of the biomass (Okaronon, 1994). This mass extinction has been attributed to predation by an introduced predator *Lales nilolicus* (Nile perch). First introduced into Lake Victoria in 1954, its numbers exploded in the early 1980s and was accompanied by rapid disappearance of the haplochromine stocks (Witte *el ai,* 1992). Although the Nile perch population boom and haplochromine crush correlate in time, it is evident that Nile perch is but one of many of the haplochromine decline (Kaufinan, 1992).

Decline in haplochromine species was accompanied by drastic changes in biological and physico-chemical conditions especially in Lake Victoria. Algal biomass in Lake Victoria increased four to five times, phytoplankton production doubled and water transparency decreased (Muggide 1992, 1993). Decay of the excess organic matter has depleted the water column of oxygen leading to development of anoxic conditions in water deeper than 40 m. This has reduced habitable space for many fish species and is thought to have driven deep water hapJochromines to shallower areas where they fell easy prey to Nile perch (Hecky, 1993). The disruption and, reduction of the diverse and trophically complex haplochromine community by the Nile perch seems to have initiated changes in food web structure of the lakes e.g by reducing pressure which may have led to accumulation of excess organic matter and some of the changes discussed above (Ogutu-Ohwayo & Hecky, 1991). Algal composition has changed and became now dominated by blue-greens. The blue-greens were the major food source of the detritivorouslplanktivorous haplochromines and the pelagic phytoplanktivores. Together these two trophic groups constituted about 50% of the total haplochromine bionass. in the lake (Goldscmidt, 1986; Witte and van Oijen, 1990). Their depletion could have reduced grazing pressure, leaving most of the algal biomass produced in the lake unconsumed.

There were differences in the rate of decline within as well as between, trophic groups (Witte *el al.,* 1992). Molluscivores, insectivores and epiphytic algal survived in the shallow littoral zone (Witte *el al* op. cit.) The Least affected were the rock frequenting haplochromines particularly the pennanent rock dwellers which live between boulders and in rock crevices in they hide from Nile perch.

Recent assessment of fish stocks of Lake Victoria have concentrated in deep waters of Lake Victoria (Okaranon, 1994) and these suggest that haplochromines and other native species are virtually absent from Lake Victoria. Some studies have, however, shown that some of the endangered species survive near shore areas especially with vegetated and rocky shores. The objective of this study was to examine the composition and relative abundance especially of haplochromine cicWids in the nearshore areas of Lake Victoria.

Objectives

The major objective of the study was to the distribution and relative abundance of the surviving haplochromines in the littoral areas of Napoleon Gulf of Lake Victoria. This was be achieved by examining:

Relative abundance and distribution of the different fish taxa.

ii Relative abundance and distribution of haplochromine speciess.

Study Areas

Specimens were collected from Napoleon Gulf in the northern region of Lake Victoria. The study covered four stations which were representative of four. habitat types namely: Rocky substrate (Rwamafuta and Kikondo); macrophyte cover habitat (Kiryowa); gentle slope (Kirinya) and steep slope (Cliff) off Jinja Club (Figure I).

The description of the sampling sites was as follows:

Kiryowa: This site is located at the mouth of the Bugungu stream. The shoreline was dominated by papyrus, *Cyperus papyrus*, with some hippo grass, *Vossia sp.*, towards the western end of the site. The shoreline vegetation was fringed by a belt of Water hyacinth, *Eichhornia erassipes*, 2-3 m wide. The area had a maximum depth of 6 m with a bottom substrate of submerged rock.

Cliff: This site is opposite the Kiryowa site. It is characterised by a steep slope ending in an exposed clay shoreline with occassional stands of *Vossia* sp. From time to time, the area was invaded by the Water hyacinth which was later transported away to the nearby source of the River Nile. The area has a maximum depth of 6 m with a bottom substrate of soft mud.

Kikondo: This site has a shoreline characterised by laterite rocks which extend into littoral area giving it a bottom substrate of hard rock. The shoreline is for most part covered by remnants of forest, in fonn of thickets which extend few metres into the Stands of cattails *(Typha* sp.) and Water hyacinth occur among the rock outcrops. Maximum depth is 10m.

Kirinya: This site is characterised by a gentle with a papyrus shoreline fringed by Water hyacinth. Maximum depth was 4 m with a bottom of soft mud.

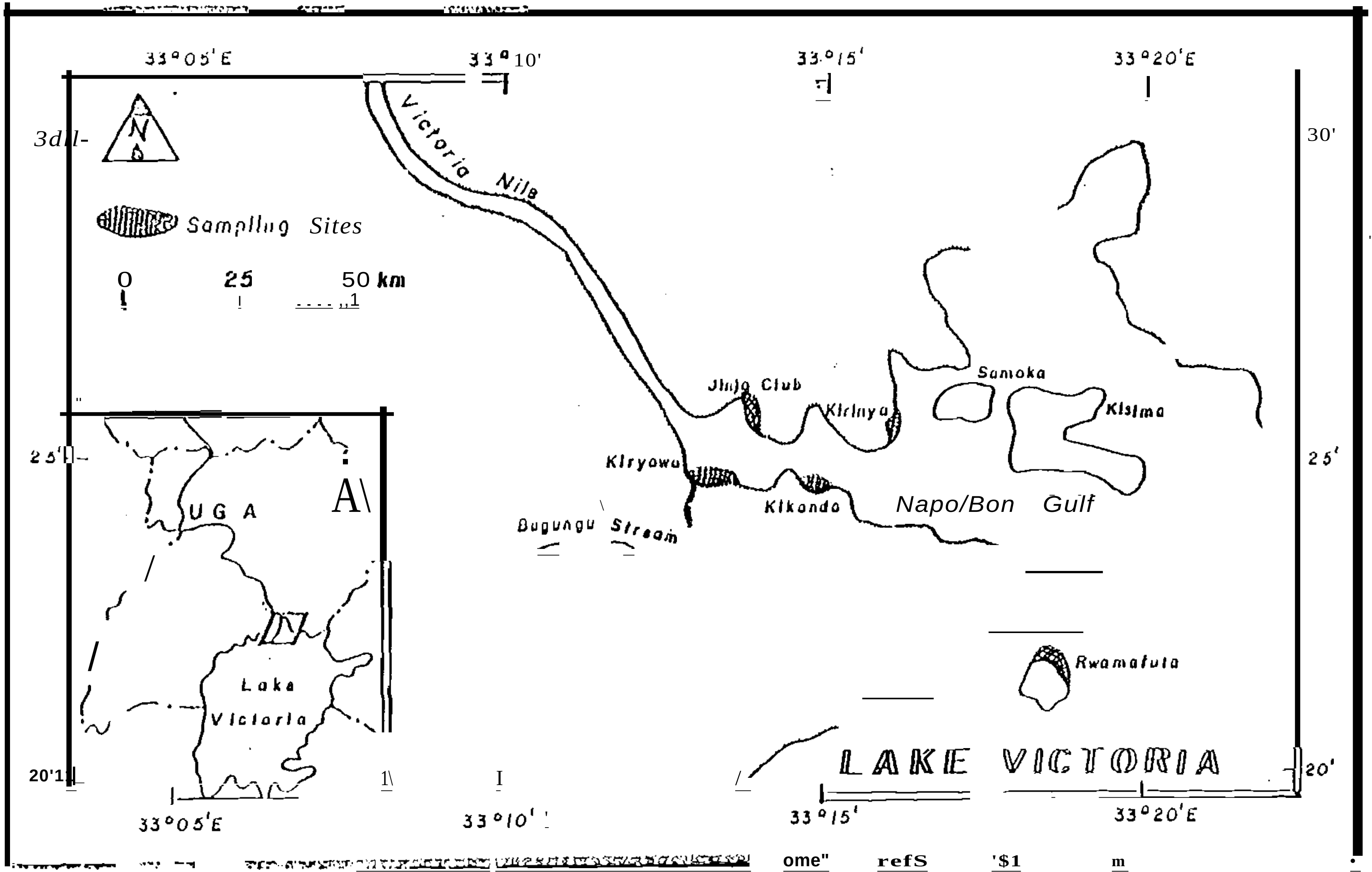


Figure I. The of Lake showiug lhe sampling arcas with an locution 'map of Uganda

Rwamafuta: This site is located on a rocky island within the Buvuma Channel. It was characterised by rocky outcrops along the shoreline and was exposed to strong waves. Most of the time the area was covered with Water hyacinth. The bottom has a substrate of submerged rock. Maximum depth was 4 m. The shoreline was exposed and composed of hard gravel.

Material and Methods.

Fish specimens were collected using three fleets of gill nets. Each fleet consisted of one net of mesh sizes 25.4 mm to 76.2 mm stretched at an interval of 12.7 mm. The three fleets of nets were, at each station, set at three locations. The first location was along the shoreline' and was regarded as having been I m from the shore. The second fleet was *at* 20m and the third fleet at 200 m from the shore. Each of these stations was sampled once a month for twelve months from October 1995 to September 1996. The nets were set at 18.00 hours in *the* evening and retrieved at 7.00 hours the following morning.

The fish caught were sorted *into* different taxonomic groups and the number and weight of the different taxa recorded. Haplochromine specimen were sorted according to mesh size of the net and the position of the fleet, and then fixed in 5% formalin. Where possible, photographs of fresh haplochromines were taken in the field to be used in later identification. Each sample was labelled with time, date, mesh size, gill net fleet location and site, and taken to the laboratory for further analysis. In the laboratory, the haplochromines were identified, where possible, to species level using the key provided by Greenwood (198 j). Identification of haplochromines to species level was based on external morphological characters especially proportional measurements, live colours, body markings, and dentition. The above characters and measurements were compared with those of the species already described to determine the species narne. Specimen not identified to species level were given cheironyrns.

In the analysis of overall relative abundance and distribution for all fish, haplochromines were lumped together as one taxa. The relative abundance and spatial distribution of fish species at each sampling station was determined by comparing the number and weight of the different fish taxa caught in the three gill net fleets at different positions from the shore. To compare relative abundance and distribution of the different fish taxa between the sites, catch data from the three nets at the different sites were pooled and compared between stations. The current data of overall relative abundance was finally compared with the pre-perch data.

Haplochromine fish species diversity was estimated using Shannon-Weaver Index of diversity H' (Pielou, 1969). The Diversity Index H' was calculated using the formula:

$$H' \quad -\sum_{i=1}^{,} p_i \log, P;$$

Where s is the number of species and Pi is the proportion by number, of each taxon in the sample.

RESULTS

Overall relative abundance and distribution for all species

Overall, twelve fish taxa were recorded from all the five stations. The overall relative importance of the most abundant fish taxa both by number and weight is illustrated in Figure 2. Numerically, Nile perch was the most dominant (42.3%) followed by haplochromines (30.7%), a. *niloticus* (12.2%), *T zi/lii* (8.9%), S. *afrofischeri* (2.3%), 8. *sadleri* (1.9%). Other fish species recorded included *M kannume,* a. *leucostictus,* S. *victoriae,* C. *gariepinus,* a. *variabilis* and *P. aethiopicus*. When weight is considered Nile perch contributed most (79.9%) followed by haplochromines (7.8%), a. *niloticus* (5.3%), *T zi/lii* (3.7%), S. *afrofischeri* (0.9%), S. *victoriae* (0.5%), 8. *sadleri* (0.5%), *M. kannume* (0.4%), a. *leucostictus* (0.2%), *P. aethiopicus* (0.2%), C. *gariepinus* (0.2%) and a. *variabilis* (0.1 %).
The average number of *L. niloticlls, Synodontis* spp. and *M. kannllme* increased from the 0 m to the 200 m positions, while that of haplochromines, a. *nilolicus* and *T zillii,* 8. *sadleri,* a. *leucoslictus,* C. *gariepinus* and *P. aethiopicus* decreased from the 0 m to the 200 m positions (Figure 3.). 0. *variabilis* was recorded only from the Om position. The highest total number of fish was recorded in the 0 m, followed by the 20 m and then the 200 m positions.

Comparison between stations

Comparison of the most abundant fish taxa between stations is illustrated in Figure 4. *L. niloticus,* haplochromines, 0. *niloticus,* and *T zillii* were recorded from all the five stations. The mean number of *L. niloticus* was highest in Rwamafuta followed by Kiryowa, Kirinya, Kikondo, and lastly, Cliff. Haplochromines were most abundant in Kiryowa followed by Kikondo, Rwamafuta, Kirinya and Cliff. 0. *niloticus* was most abundant in Kiryowa followed by Rwamafuta, Kikondo, Cliff and Kirinya. The highest number of *T zillii* was recorded from Rwamafuta followed by Kiryowa, Kikondo, Kirinya and Cliff. S. *afrofischeri* was most abundant in Cliff followed by Rwamafuta, Kikondo, Kiryowa and Kirinya. 8. *sadleri* occurred mostly in Kirinya followed by Kiryowa, Kikondo, Rwamafuta and Cliff.

Overall relative abundance and distribution of haplochromines

Overall, twenty two haplochromine species were recorded from all the five stations (Table 1) and these included *Astatoreochromis alluaudi, Paralabidochromis "goldchest", Astotilapia sp., Astatotilapia "bicuspid", Astotilapia nubila, Astatotilapia "unicuspid", Neochromis nigricans, Neochromis pseudonigricans, Neochromis "scraperteelh", Paralabidochromis "big eye", Paralabidochromis "blue deep-body", Paralabidochromis chi/otes, Paralabidochromis crassilabris, Paralabidochromis "curved head", Parabidochromis "rockcribensis", Paralabidochromis "sharpteeth", Paralabidochromis "shortsnoUl", Paralabidochromis "velvetblack", Paralabidochromis "yellowbars", Paralabidochromis "yellowbody", Ptyochromis xenognathus, Harpagochromis guiarli* and *Prognathochromis paraguiarti*.

The overall relative abundance of the most abundant haplochromine species both by number and weight is illustrated in Figure 5. When numbers are considered, *A. alluaudi* was the most dominant (17.9%) followed by *A. "unicuspid"* (14.8%), *P. paraguiarti* (12.7%), *P. "yellowbody"* (10.6%), *P. "goldchest"* (9.8%), *H. guiarti* (7.5%), *A. nubila* (6.5%), *A. "bicllspid"* (4.2%), *N "scraperteeth"* (3.2%), *N nigricans* (2.8%), *P. crassilabris* (1.6%), *P. "velvetblack"* (1.6%), *P. "yellowbar"* (1.3%), *N pseudonigricans(I.2%), P. rockcribensis*

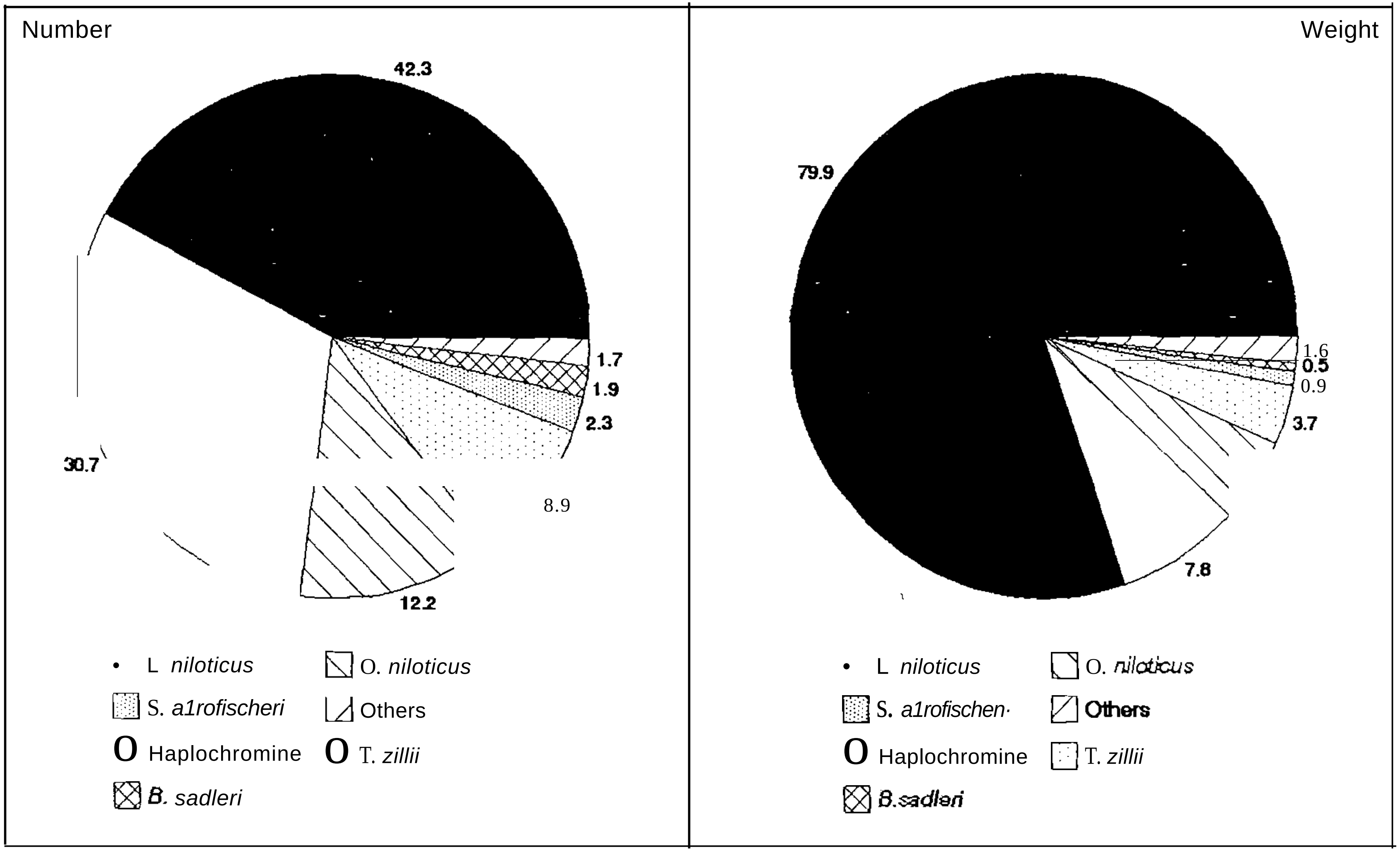


Fig. 2. Overall relative abundance of fish taxa, by number and weight.

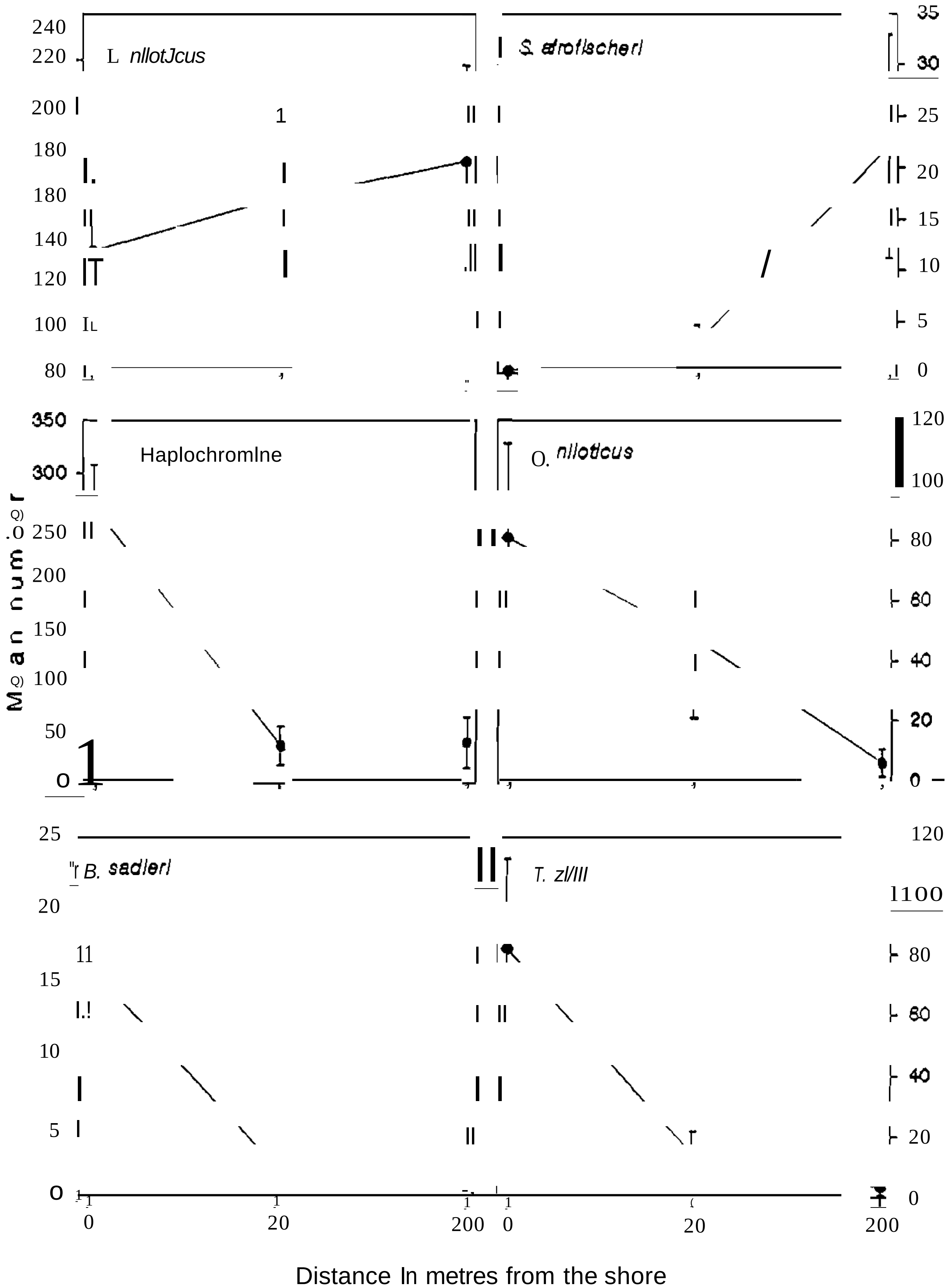


Fig.3. **Overall distribution of dominant fish taxa**

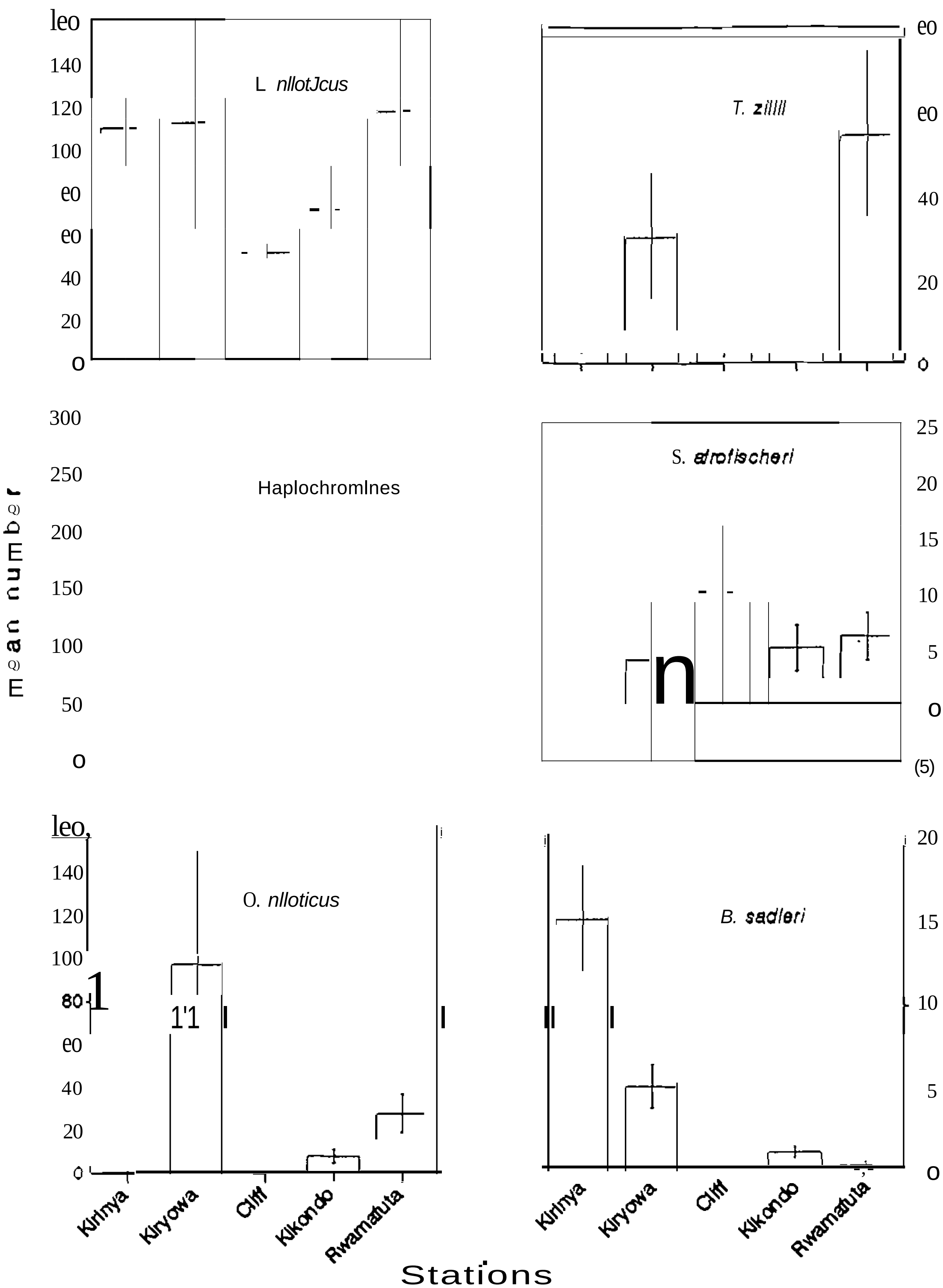
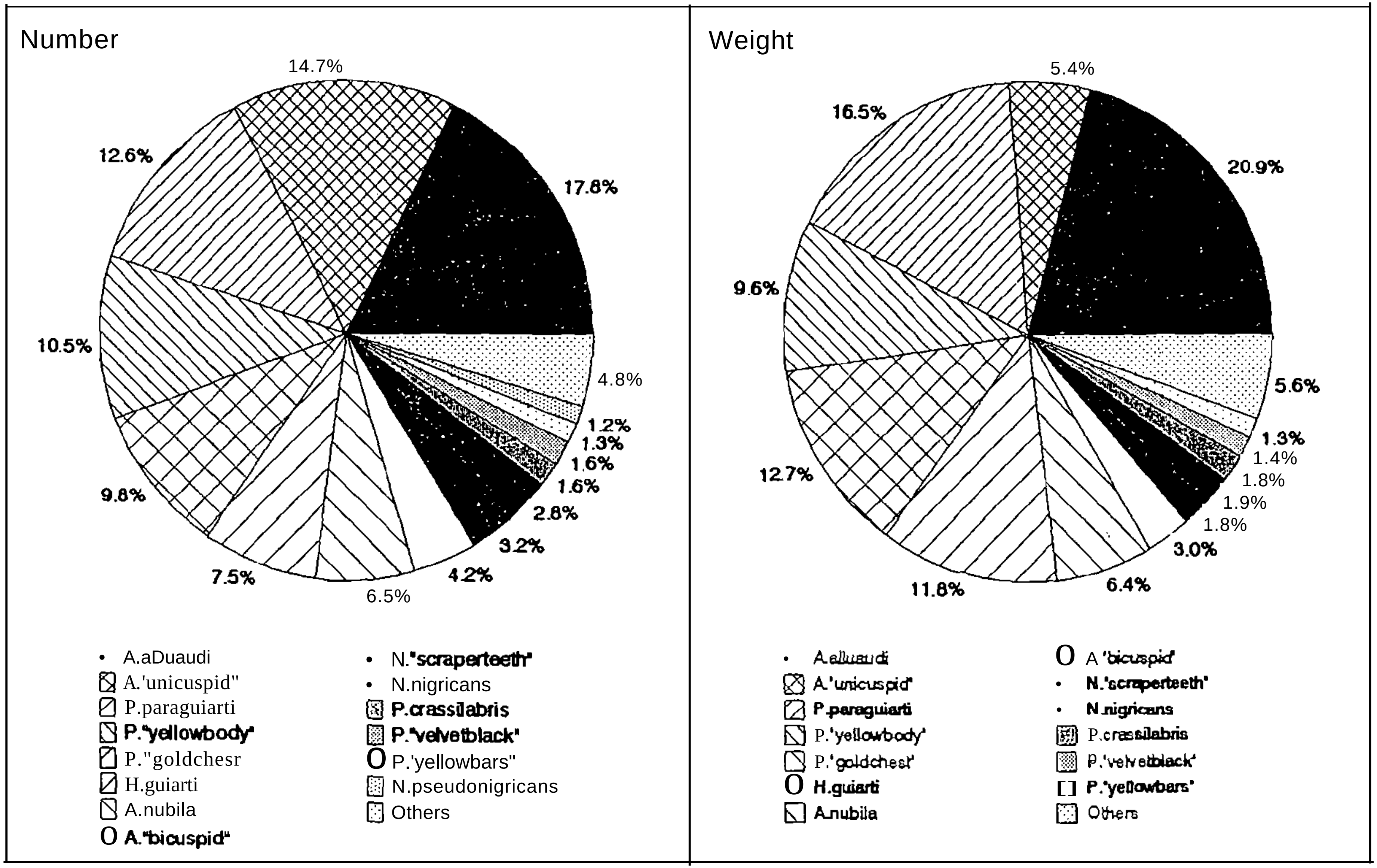


Fig. 4. Comparison of fish taxa abundance between different stations

Table I. The numerical abundance of haplochromine species at each station in the study area

Species	Kirinya	Kiryowa	Cliff	Kikondo	Rwama futa	Total
A.al/uaudi	5	304	0	6	I	316
P. "goldchest"	27	154	20	12	20	233
Astatotilapia sp.	0	18	0	0	0	18
A. "bicuspid"	I I	34	3	14	25	87
A.nubila	45	110	I	3	1	160
A. "unicuspid'l	8	45	27	289	3	372
N. nigricans	0	I	0	2	76	79
N. pseudonigricans	0	0	0	4	29	33
N. "scraperteeth "	0	18	12	45	I	76
P. "big eye"	0	16	0	3	0	19
P. "blue deep-body"	0	23	0	3	I	26
P.chilotes	I	3	0	12	I	16
P. crassilabris	0	18	0	7	13	38
P. "curved head"	0	10	0	0	0	10
P. "rockcribensis"	I	2	2	4	10	19
P. "sharpteeth "	0	3	0	0	0	3
P. "shortsnout"	0	2	0	0	3	5
P. "velvetblack"	0	20	0	2	16	38
P. "yel/owbars"	0	10	0	4	0	14
P. "yel/owbody"	0	0	0	0	245	245
P.xenognathus	0	1	I	12	0	14
H.guiarti	22	113	7	33	0	175
P.paraguiarti	0	99	52	163	I	315
TOTAL	120	1004	125	618	446	2313



Rg.5. Overall relative abundance of haplochromine species by number and weight

(0.9%), ASlalOli/apia sp. (0.8%), P. "shorlsnoul" (0.7%), P. "blue deep-body" (0.6%), P. xenognalhus (0.5%), P. "sharpleelh" (0.4%), P. "bigeye" (0.4%), P. chi/oles (0.2%), and *P. "curved head" (0.2%),* By weight, the most dominant species was *A. alluaudi (20.9%)* followed by *P. paraguiarli* (16.5%), *P. "goldchesi"* (12.7%), *H guiarli* (11.8%), *P. "yellowbody" (9.6%), A. nubila* (6.4%), *A. "unicuspid"* (5.4%), *A. "bicuspid" (3.0%), Nnigricans* (1.9%), *N "scraperleelh"* (1.8%), *P. crassilabris* (1.8%), *P. "velvelblack"* (1.4%), *P. "yellowbars"* (1.3%), *N pseudonigricans (0.9%), P. rockcribensis (0.9%), ASlaloli/apia sp. (0.6%), P. "bigeye" (0.5%), P. xenognalhus (0.4%), P. chi/oles (0.3%), P. "curved head" (0.3%), P. "sharpleelh" (0.3%),* and *P. "shorlsnoul" (0.3%).*

Distribution of the different haplochromine species varied with distance from the shoreline (Figure 6). *P. chi/oles, P "bigeye"*, and *P. "curved head"* occurred only at the 0 m position while *ASlaloli/apia sp.* occurred only in the *200* m position. The average number of *A. "unicuspid"* increased from the 0 m to the *200* m positions, while that of the remaining species decreased from the 0 m to the *200* m position. Haplochromine species diversity at the different stations based on Shannon Weaver Index of Diversity is illustrated in Figure 7. Haplochromine species diversity was lowest at Cliff (0.52),followed by Kirinya *(0:54),* Rwamafuta *(0.72),* Kikondo (1.12), and Kiryowa (1.52).

Population structure of haplochromines

The length frequency distribution of the most dominant haplochromine species is illustrated in Figure 8. Virtually all the haplochromine cichlids caught were between 6 cm and 19 cm total length. The size range of the different species was as follows: 8 cm to 15 cm for *A. alluaudi,* 8 cm to 19 em for *P. paraguiarli,* 6 cm to 12 cm for *A. "unicuspid",7* cm to 15 cm for *P. "yellowbody",* 8 cm to 16 cm for *P. "goldchesl",* 9 cm to 18 cm for *H guiarli,* 8 cm to 16 cm for *A. nubi/a,* 7 cm to 12 cm for *A. "bicuspid",* 8 cm to 16 cm for *N nigricans,* 7 cm to 15 cm for *N "scraperleelh",* 8 em to 15 cm for *P. "velvelblack"* and 8 cm to 17 cm for *P. crassilabris.*

Relative abundance and distribution of haplochromines within stations.

Kiryowa

Twenty haplochromine species were recorded from Kiryowa. The relative importance of the most abundant haplochromine species from Kiryowa both by number and weight is illustrated in Figure 9. When numbers are considered, the most abundant species were, in order of importance, *A. alluaudi* (37%), *P. "goldchesl"* (13.8%), *H guiarli* (10.3%), *A. nubila* (9.2%), *P. paraguiarli* (9.2%), *A. "unicuspid"* (4.5%), *A. "bicuspid* "(4.4%), *P. "velvelblack" (1.8%), ASlaloli/apia sp.* (1.7%), *P. crassi/abris* (1.6%), *N "scraperleelh"* (1.6%), *P. "blue deep-body" (1%), P. "yellowbars"* (1%), *P. "sharpleelh"* (1%), *P. "bigeye" (0.8%), P. chiloles (0.3%), P. "rockcribensis" (0.3%), P. "shorlsnoul"* (0.2%), *N nigricans* (0.1 %) and *P. xenognalhus (0.1%).* When weight is considered *A. alluaudi* contributed most (37.2%) followed by *P. "goldchesl"* (16.2%), *H guiarli* (14.6%), *P. paraguiarli* (9.1%), *A. nubi/a* (8.3%), *A. "bicuspid"* (3.4%), *P. crassi/abris* (1.7%), *P. "blue deep-body"* (1.5%), *A. "unicuspid" (1.4%), ASlaloli/apia sp.* (l.t%), *P "bigeye" (0.9%), N "scraperleelh" (0.9%), P. "velvelblack" (0.8%), P. "sharpleelh"* (0.6%), *P. chi/oles* (0.4%), *P. "shorlsnoul"* (0.3%), *P. rockcribensis* (0.2%), *P." yellowbars" (0.2%), P. xenognalhus* (0.1 %), and *N nigricans (0.03%).*

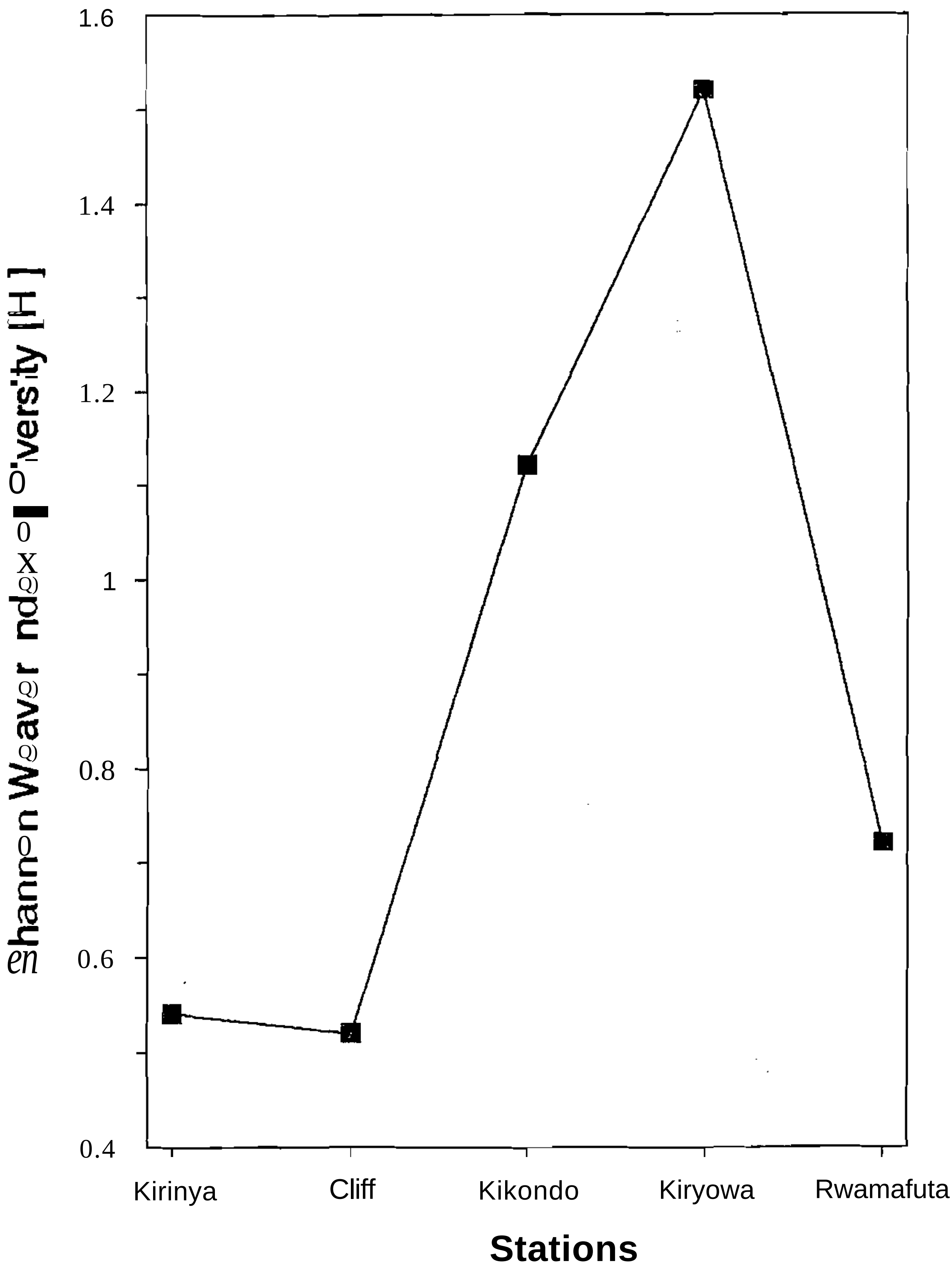


Fig. 7. Comparison of haplochromlne species diversity at different stations

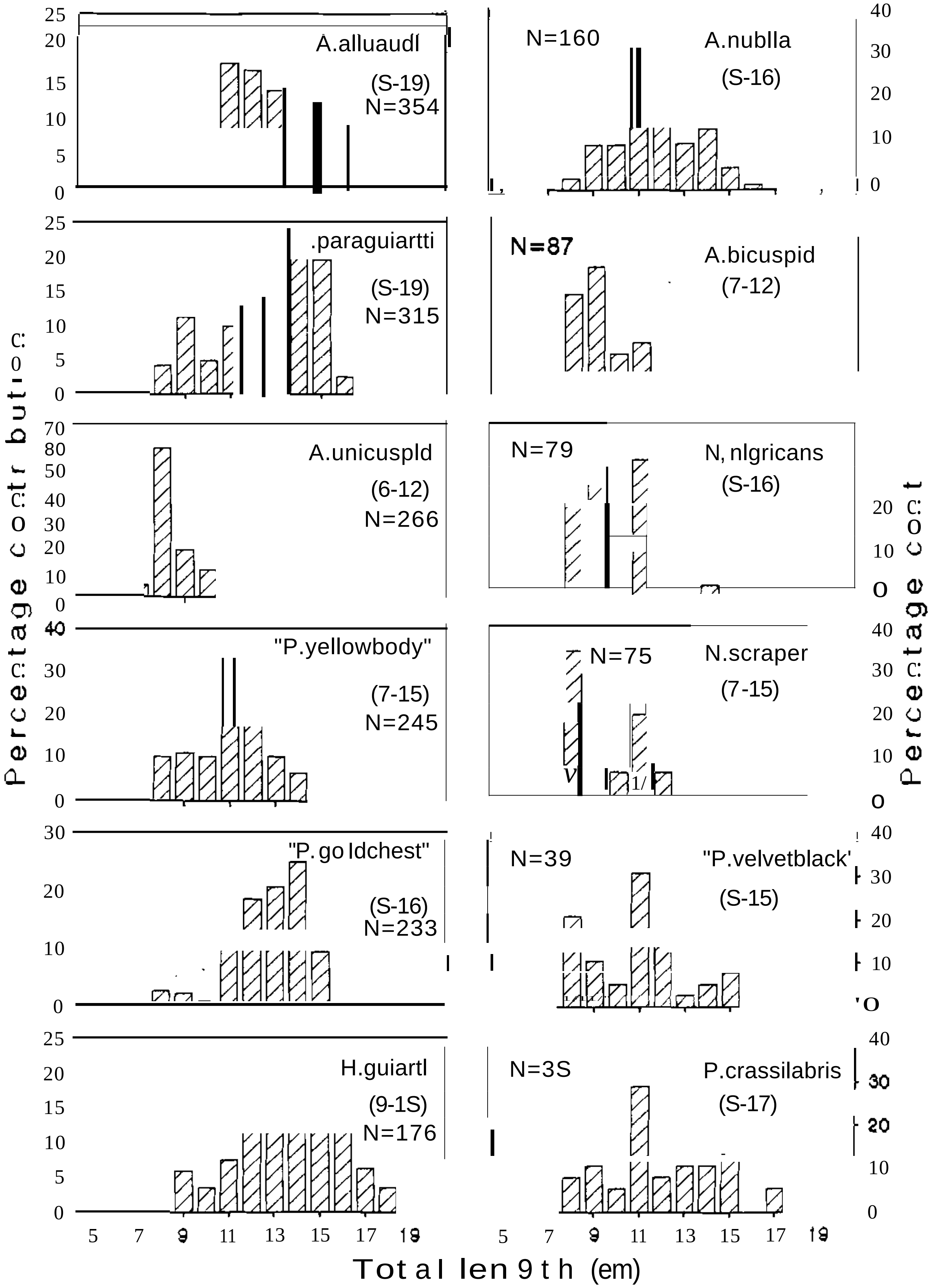
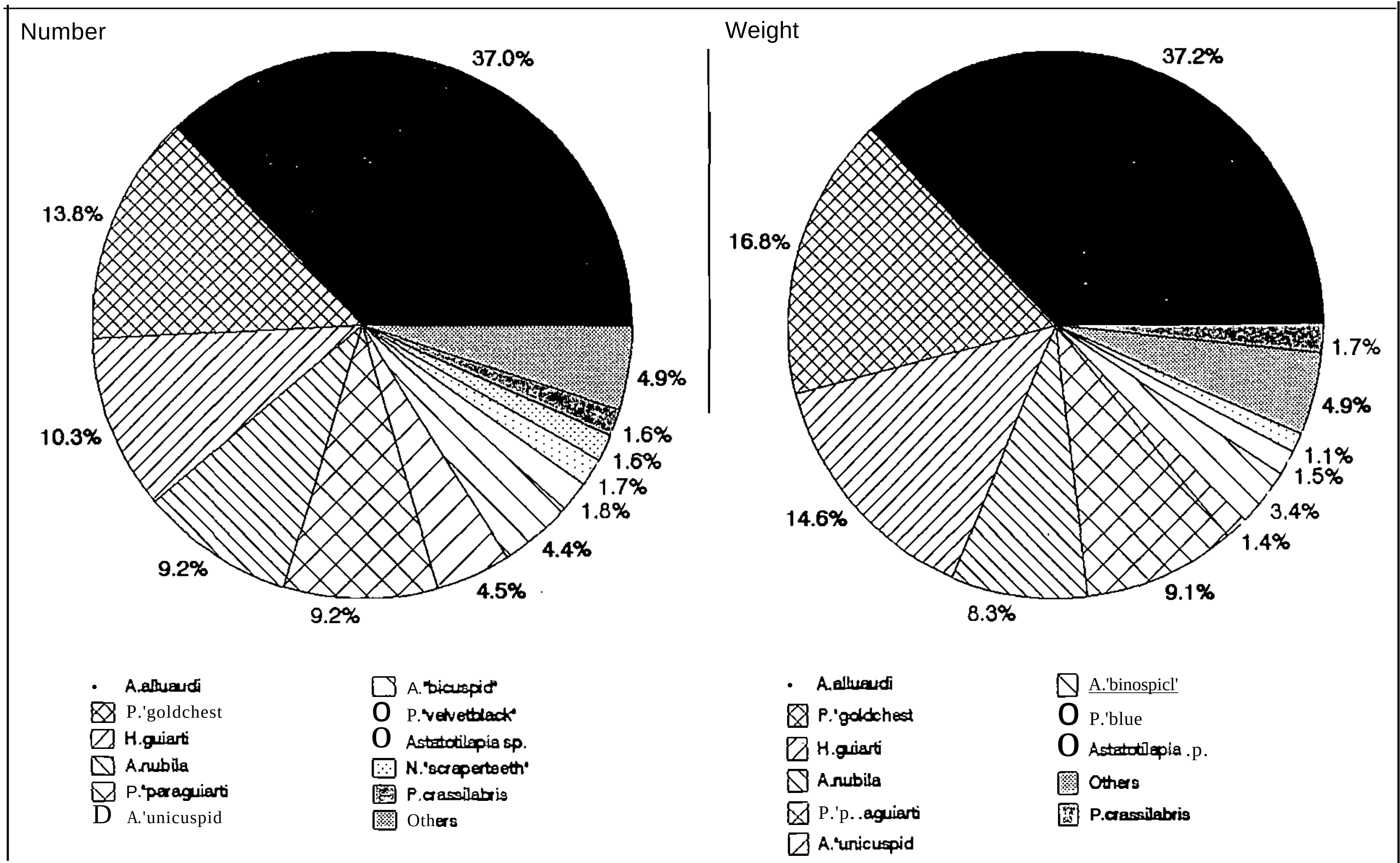


Fig. S. Length frequency distribution of the dominant haplochromine species



Rg. 9. Relative abundance, by number and weight, of haplochromine species from Kiryowa

The distribution of the different haplochromine species varied from inshore to offshore (Figure 10). The average number of *A. alluaudi*, *P. "goldchesl"*, *H guiarli*, *P. paraguiarli*, and *A. nubila* decreased from the 0 m to the 200 m positions while that of *A. "unicuspid"* increased from the 0 m to the 200 m positions. *P. xenogna/hus* and *N nigricans* occurred only in the 20 m position, while *P. "velvelblack"* and *P. chiloles* occured only in the 0 m position.

Cliff

Eight haplochromine species were recorded from Cliff. The relative importance of the most abundant haplochromine species at Cliff both by number and weight is illustrated in Figure II. By number, the order of abundance was *P. paraguiarli* (38.2%), *A. "unicuspid"* (21.5%), *P. "goldchesl"* (15.3%), *N "scraperleelh"* (8.3%), *P. ·"yellowbars"* (5.5%), *H guiarli* (4.9%), *A. "bicuspid"* (2.1 %), *P rockcribensis* (1.4%), *N nigricans* (1.4%), *A. nubila* (0.7%) and *P. xenognalhus (0.7%).* When weight is considered *P. prognalhochromis* (5/.4%) was the most dominant followed by *P. "goldchesl"* (19.9%), *P. "yellowbars"* (7.9%), *A.. "unicuspid" (6.9%), H guiarli* (5.2%), *N "scraperlee/h"* (4.3%), *A. nubila* (1.1%), *P.xenogna/hus* (1.0%), *N nigricans* (0.8%), A *"bicuspid"* (0.7%) and *P. "rockcribensis" (0.6%).*

Distribution of the different haplochromine species varied from inshore to offshore (Figure 12). The average number of *P. "goldchesl"* decreased from the 0 m to the 200 m positions, while that of *A. "unicuspid"* was equal at all the three positions. *P. "rockcribensis"* occurred at the 0 m and 20 m positions. The remaining haplochromine species occurred only in the 0 m position.

Kikondo

Seventeen haplochromine species were recorded from Kikondo. The relative importance of the most abundant species at Kikondo both by number and weight is in Figure 13. When numbers are considered, the most abundant species were *A. "unicuspid"* (47.3%), *P. paraguiarti (25.4%), N "scraperleelh"* (8.4%), *H guiarli* (6.2%), *A: bicuspid"* (2.6%), *P. xenognathus (1.9%) P. "goldches/"* (1.5%), *P. crassilabris* (1.1%), *P. "yellowbars"* (1.1%), *A. alluaudi (0.9%), N pseudonigricans* (0.7%), *P "curved head"* (0.7%), *A. nubila* (0.6%), *P. "blue deep-body"* (0.4%), *N nigricans* (0.4%) and *P. "velvelblack"* (0.2%). When weight is considered, *P paraguiarli* contributed most (42.8%) followed by *A. "unicuspid"* (21.7%), *H guiarli (12.4%), N "scraperleelh"* (5.0%), *P. "goldchesl"* (2.5%), *P crassilabris* (2.5%), *A. "bicuspid" (2.2%), P "yellowbars"*, *P. xenognalhus* (1.7%), *P. "curved head"* (1.4%), *N nigricans* (1.2%), *A. alluaudi* (1.2%), *P. "blue deep-body"* (1.0%), *A. nubila* (1.0%), *N pseudonigricans* (0.8%) and *P. "velvelblack" (0.4%).*

The distribution of the different haplochromine species varied from inshore to offshore (Figure 14). The average number of *P. paraguiarli* and *N "scraperleelh"* decreased from the 0 m to the 200 m positions while that of *A. "unicuspid"* increased from the 0 m to the 200 m positions. The remaining species occurred only in the 0 m position

Kirinya

.. Seven haplochromine species were recorded Kirinya. The relative importance of the most abundant haplochromine species at Kirinya both by number and weight is illustrated in Figure 15. When numbers are considered the most abundant species were, *A. nubila* (35.2%), *P. "goldchesl"* (21.1 %), *H guiarli* (17.2%), *A. "bucuspid"* (7.0%), *A. "unicuspid"* (6.2%), *P.*

"yellowbars" (4.7%), *A. alluaudi* (4.7%), *P. paraguiarli* (2.3%), *P. chiloles* (0.8%), *P. rockcribensis* (0.8%). When weight is considered, *A. nubila* contributed most (30./ %) followed by *H guiarli* (22.1%), *P. "goldchesl"* (18.9%), *A. alluaudi* (8.1%), *P. "yellowbars"* (6.7%), *A. "bicuspid"* (4.8%), *P. paraguiarli* (4.3%), *A. "unicuspid"* (2.6%), *P. "rockcribensis"* (1.6%) and *P. chiloles (0.7%).*

Distribution 'Jf the different haplochromine species varied from inshore to offshore (Figure 16). The average number of *A. nubila, P. "goldchesl", H guiarli,* and *A. "unicuspid"* decreased the 0 m to the 200 m positions. *A. "bicuspid", A. alluaudi,* and *P. chiloles* occurred only in the 0 m position. *P. "yellowbars"* and *P. paraguiarli* occurred in the 0 m and 200 m positions while *P. "rockcribensis"* occrred only in the 20 m position.

Rwamafuta

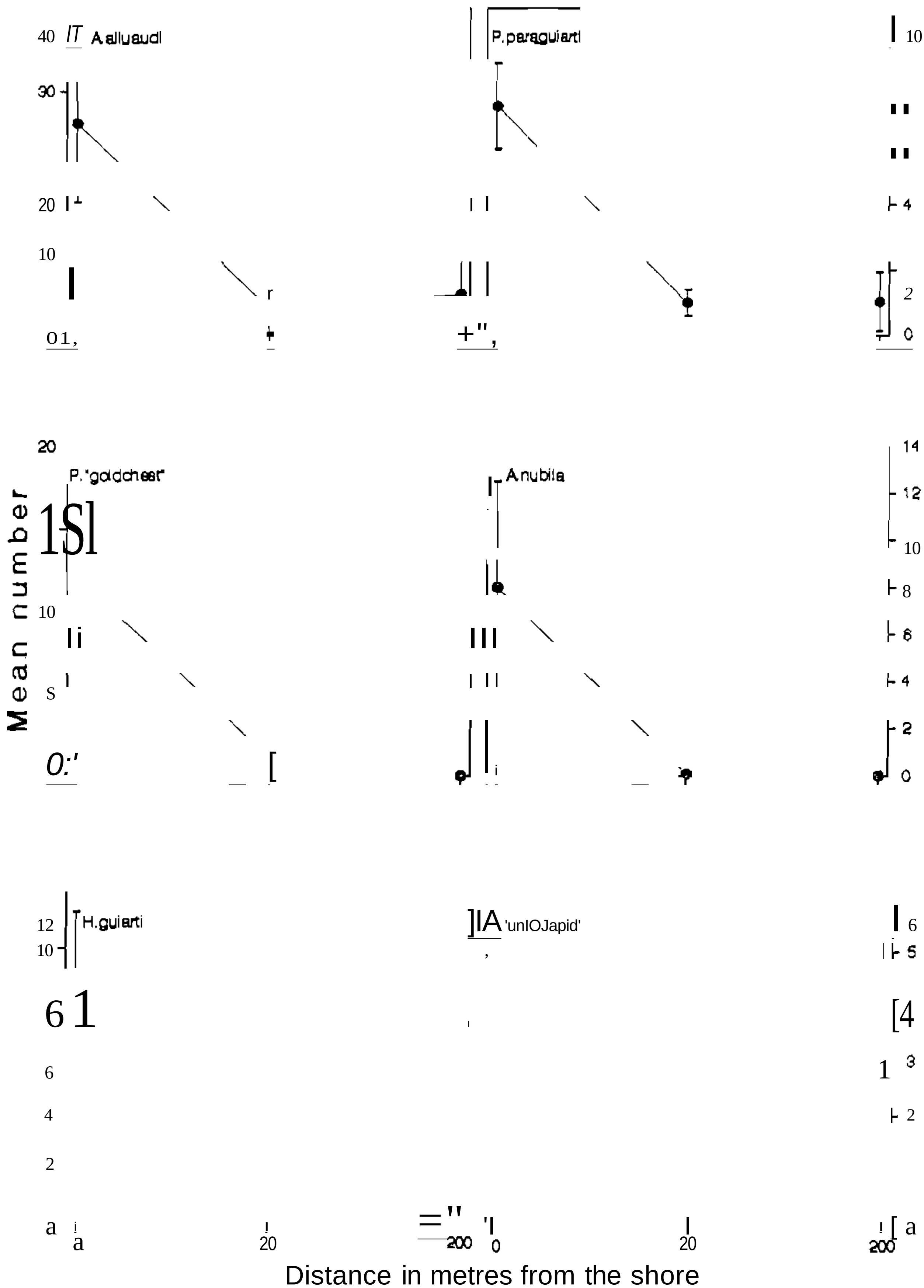
Fifteen haplochromine species were recorded from Rwamafuta. The relative importance of the most dominant haplochromine species at Rwamafuta both by number:.and weight is illustrated in Figure 17. Numerically, *P. "yellowbody"* (57.6%) contributed most followed by *N. nigricans (13.9%), N. pseudonigricans* (5.8%), *A. "bicuspid"* (5.8%), *P. "goldchesl"* (4.7%), *P. "velvelblack"* (3.7%), *P. crassilabris* (3.0%), *P. rockcribensis* (2.6%), *A. "unicuspid"* (0.7%), *P. "shorlsnoul"* (0.7%), *A. alluaudi* (0.2%), *P. paraguiarli* (0.5%), *A. nubila* (0.2%), *N. "scraperleelh"* (0.2%), and *P. guiani* (0.2%). When weight is considered *P. "yellowbody"* was the most dominant (61.7%) followed by *N. nigricans* (10.3%), *P. "goldchesl"* (5.6%), *N. pseudonigricans* (4.7%), *P. rockcribensis* (3.8%), *P. crassilabris* (2.8%), *A. "bicuspid" (2.7%), P. "velvelblack"* (0.7%), *P paraguiarli* (0.7%), *A. alluaudi* (0.4%), *H guiarli* (0.3%), *A. "unicuspid"* (0.3%), *N. "scraperleelh"* (0.2%), and *A. nubila (0.2%).*

Distribution of the different species varied inshore to offshore (Figure 18). The average number of *P. "yellowbody", N. nigricans, P. "velvelblack"* and *P: crassilabris* decreased the 0 m to the 200 m position while that of *P. rockcribensis* increased from the 0 m to the 200 m positions. *N. pseudonigricans, A. "bicuspid", N. "scraperleelh",* and *A. nubila* occurred only at the 0 m position.

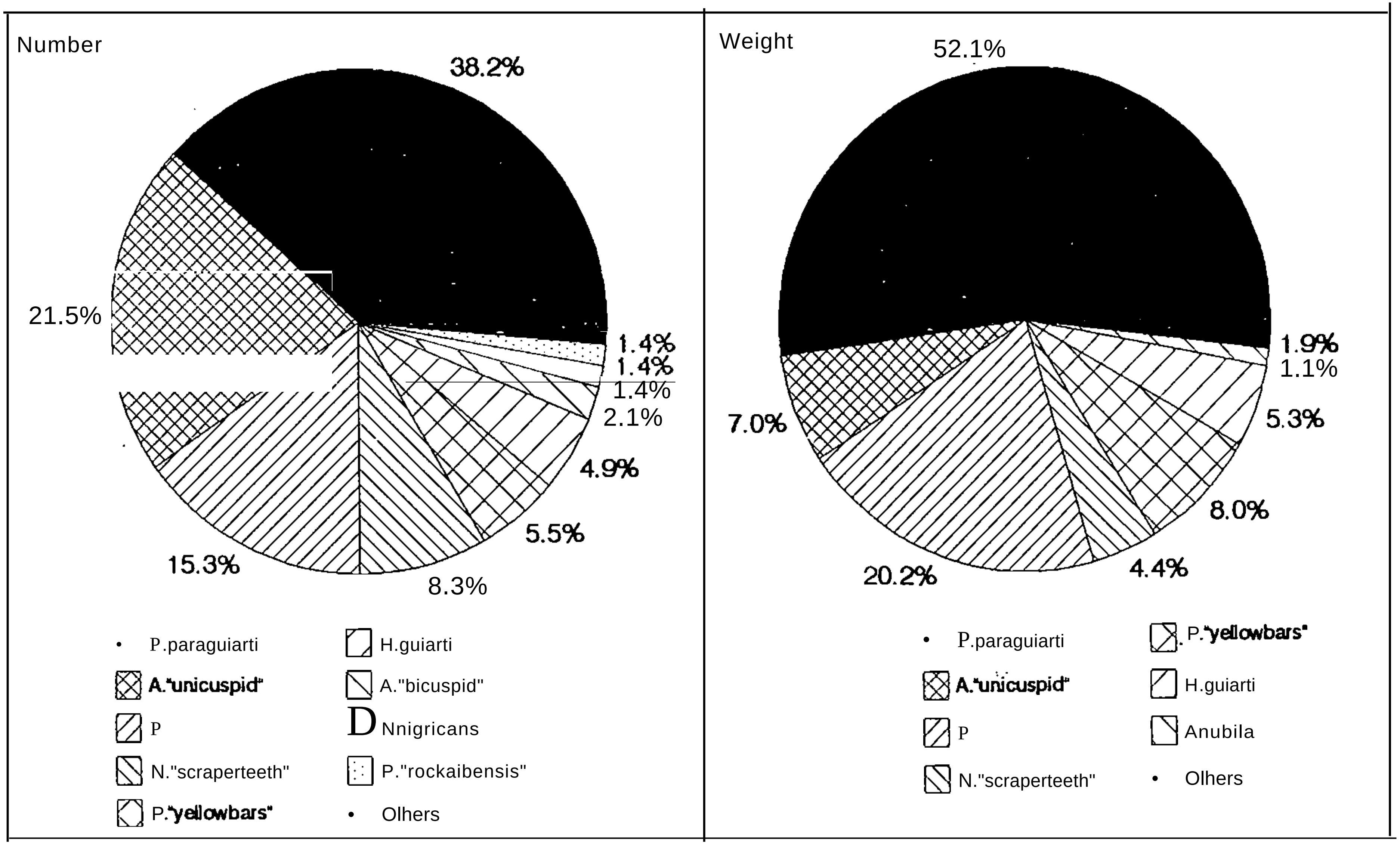
Discussion

Comparison of current relative abundance with historical data is illustrated in Figure 19. In the present study, twelve fish taxa were recorded. When numbers are considered, *L. nilolicus* contributed most followed by haplochromines, 0. *nilolicus, T zillii,* S. *afrofischeri, B. sadleri, M kannume,* 0. *leucosliclUS,* S. *vicloriae,* C. *gariepinus,* 0. *variabilis,* and *P. aelhiopicus.* When only native fish taxa are considered, the most abundant was haplochromines followed by S. *afrofischeri, B. sadleri, M kannume,* S. *vicroriae,* C. *gariepinus,* 0. *variabilis* and *P. aelhiopicus.* 0. *variabilis* was the only native tilapine recorded.

In gill net surveys carried out in the Napoleon Gulfby EAFFRO in 1956/57, before introduction of exotic species, twelve fish taxa were recorded (Figure 19). The most dominant taxa, numerically, by then was haplochromine cichlids (48%) followed by *M kannume* (22.5%), *B. docmac* (8.7%), *Tilapia spp.* (7.4%), *Labeo viclorianus* (5.2%), C. *mossambicus (1.9%), Gnalhonemus spp.(1.8%), Alesles spp.* (1.4%), *P. aelhiopicus* (1.2%), *B. allianalis (1%), Mormyrus macrocephalus* (0.6%) and *Marcusenius spp.* (0.3%). The tilapiines included 0.



Fig, 10, Distribution of dominant haplochromine species from Kiryowa



Rg. 11. Relative abundance, by number and weight, of haplochromine species from Cliff

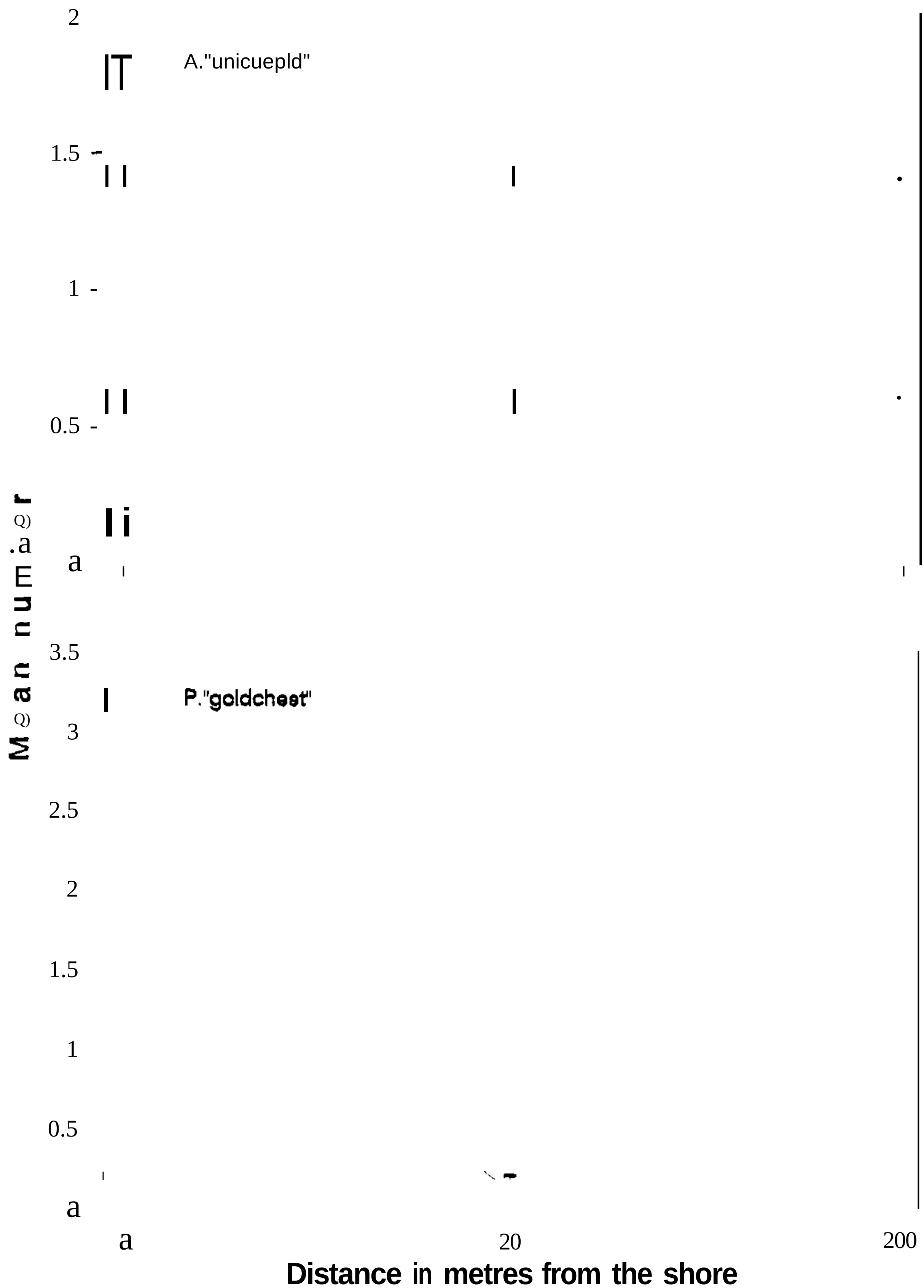


Fig. 12. Distribution of dominant haplochromlne species from Cliff

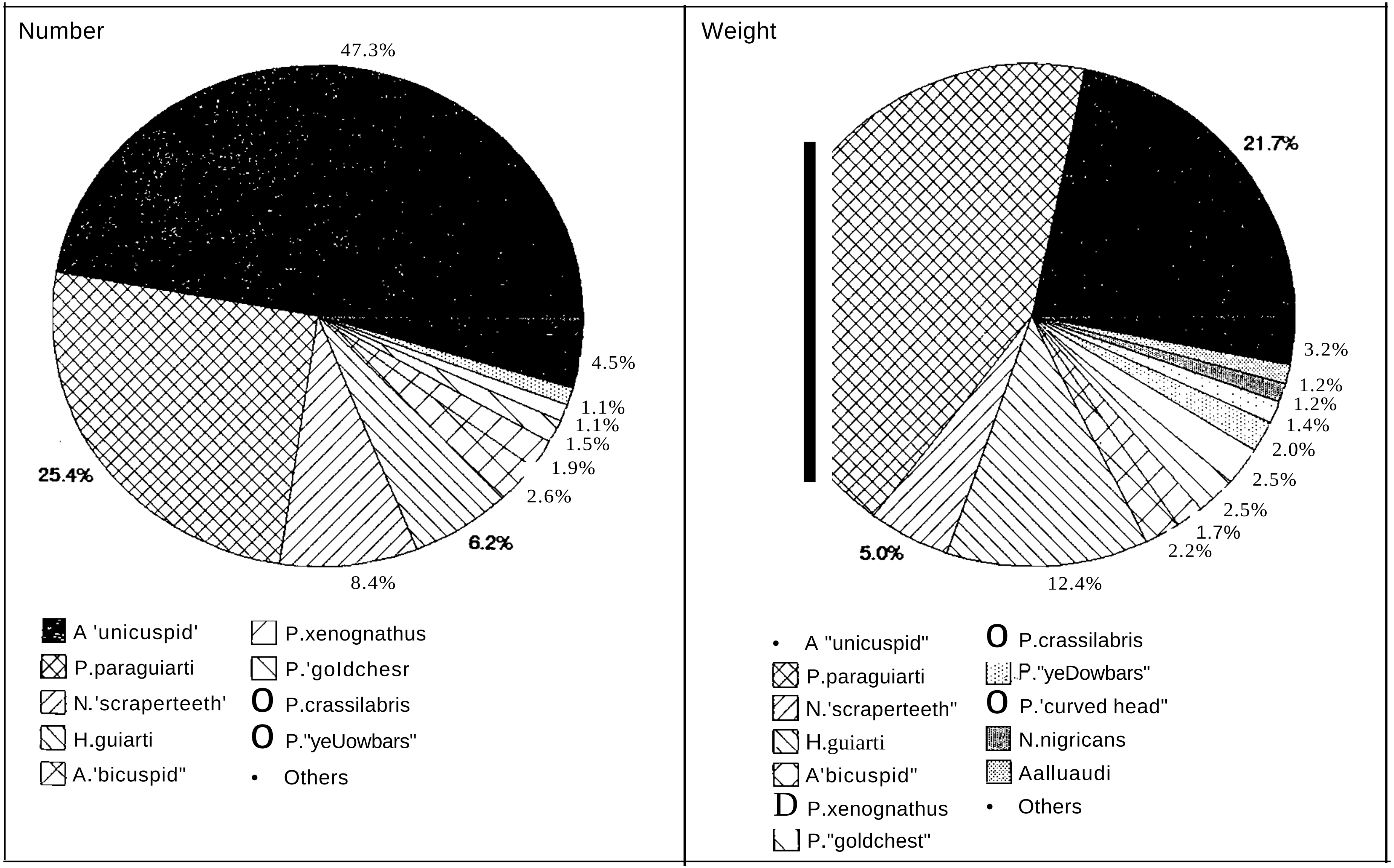


Fig. 13. Relative abundance, by number and weight, of haplochromine species from Kikondo

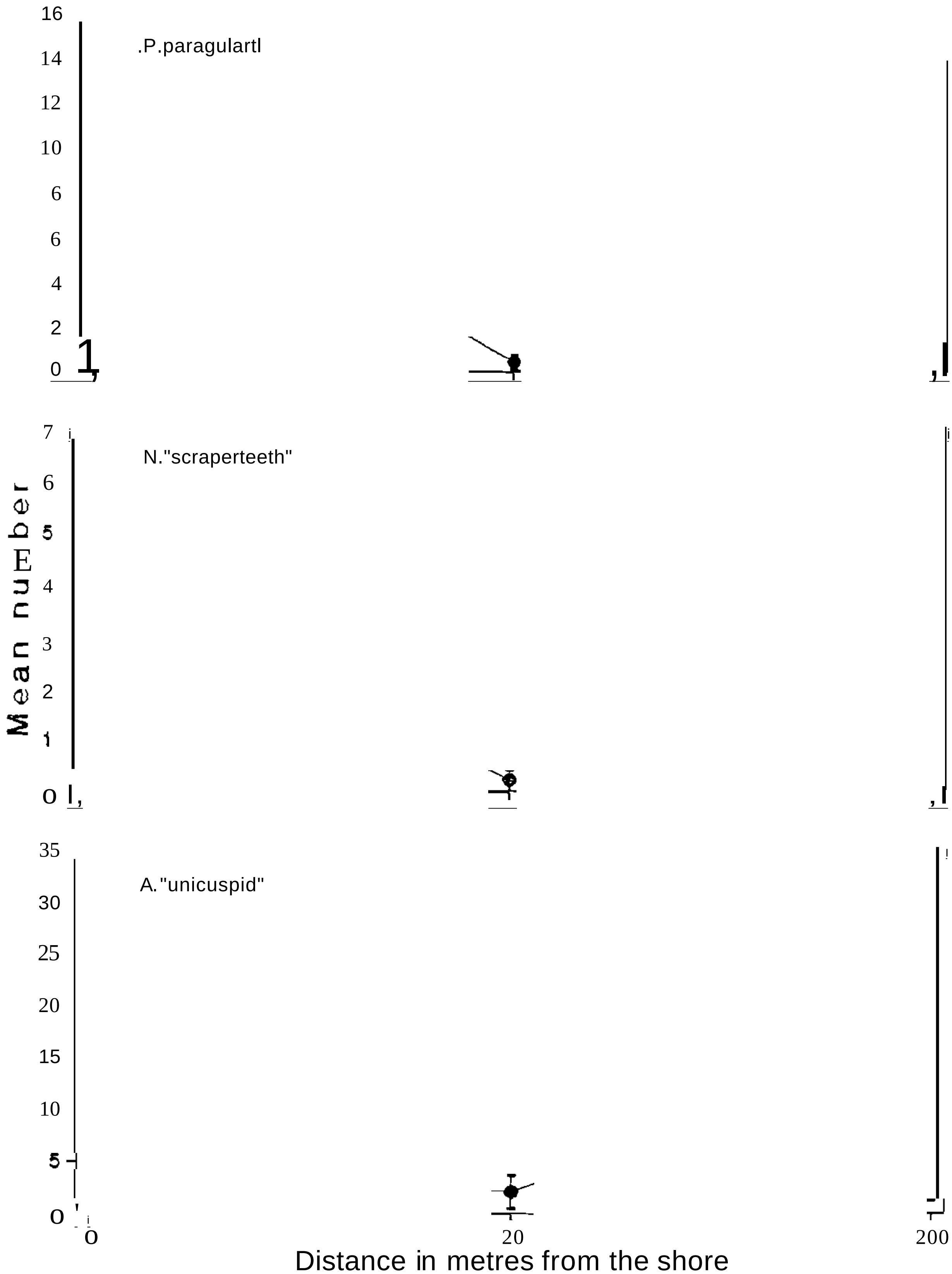


Fig. 14, Distribution of dominant haplochromlne species from KIkondo

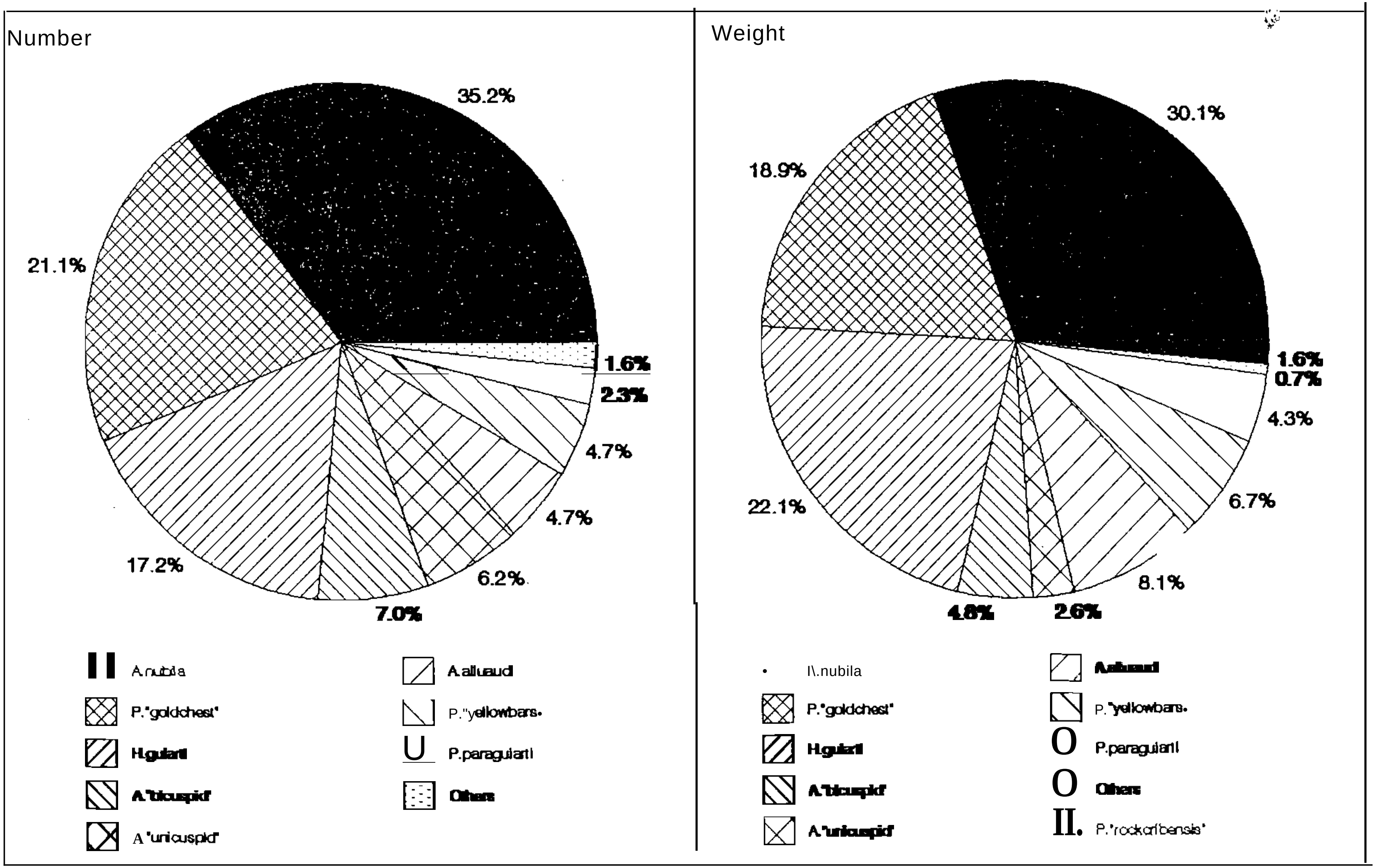


Fig. 15. Relative abundance, by number and weight, of haplochromine species from Kirinya

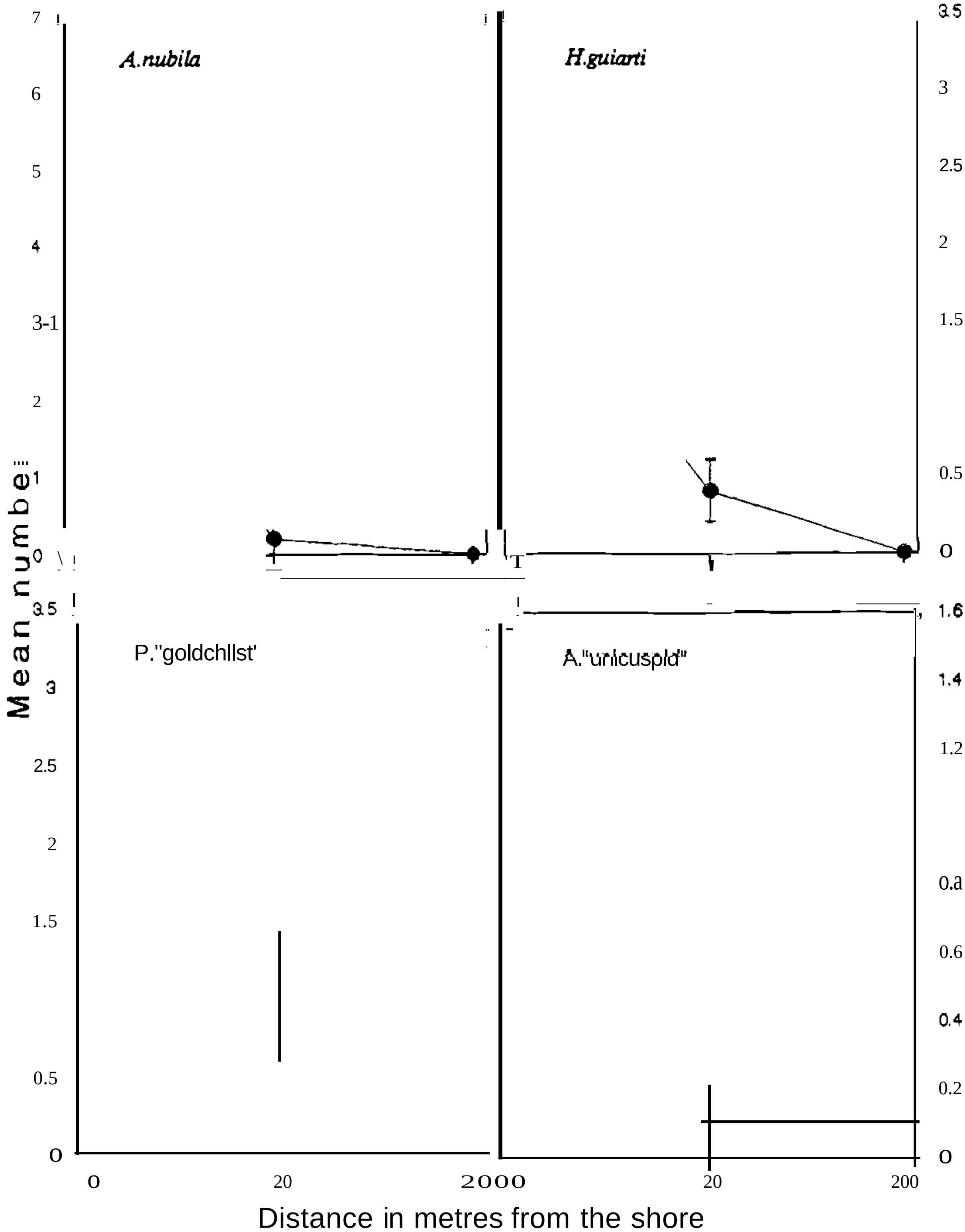
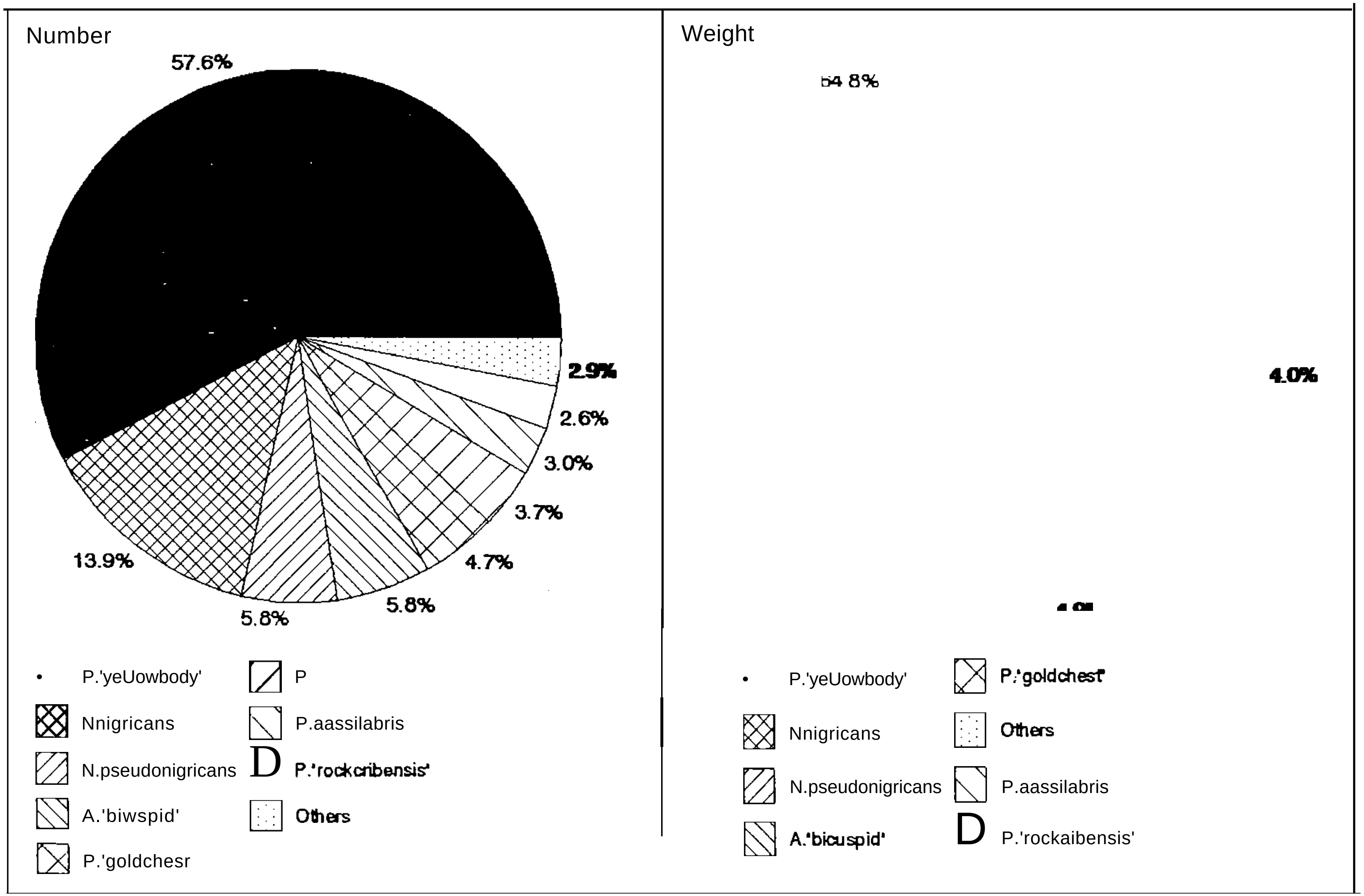
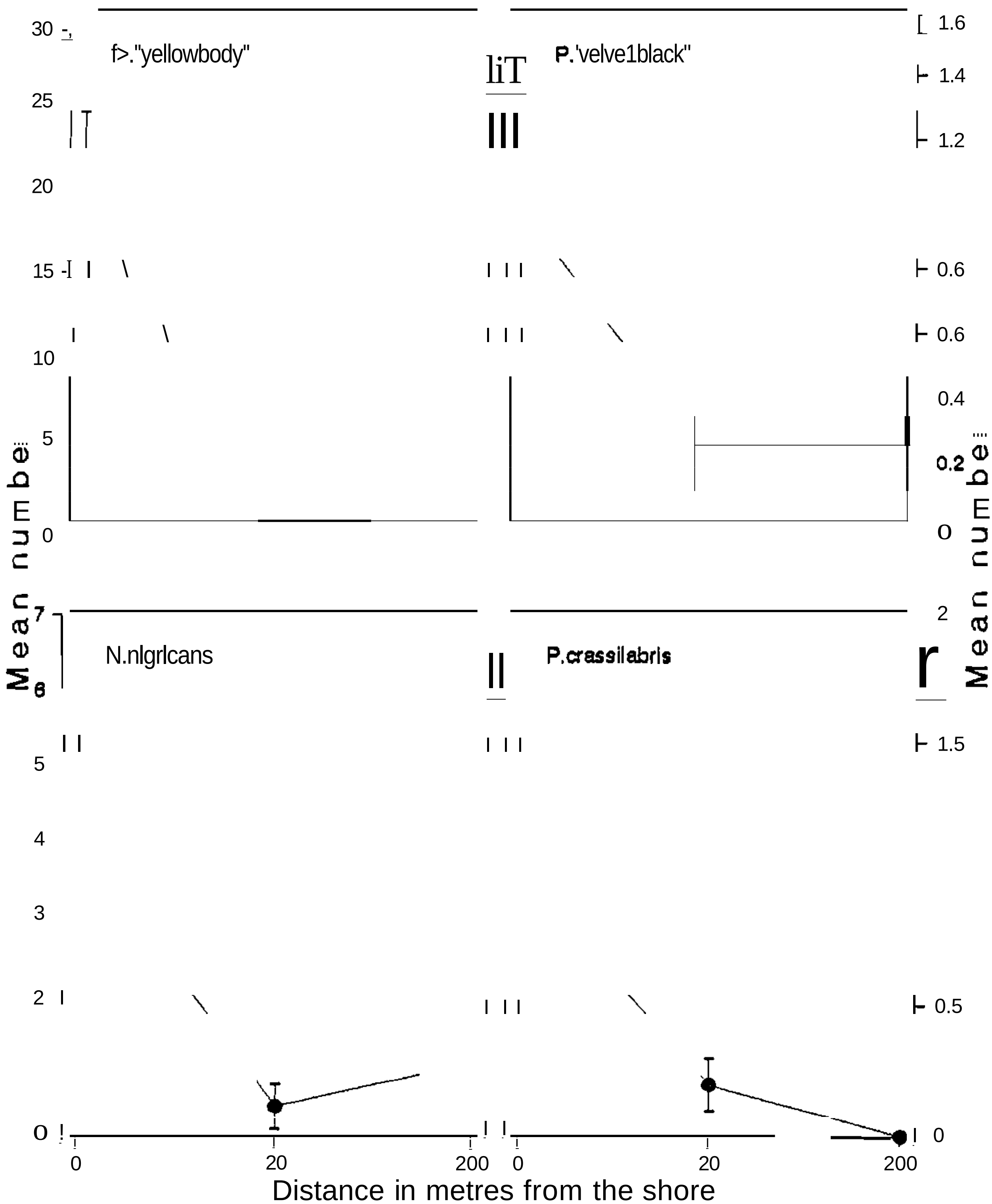


Fig. 16. Distribution of dominant haplochromlne species from Klrlnya



Rg. 17. Relative abundance, by number and weight, of haplochromine species from Rwamafuta



Fig, 18, Distribution of dominant haplochromlne species from Rwamafuta

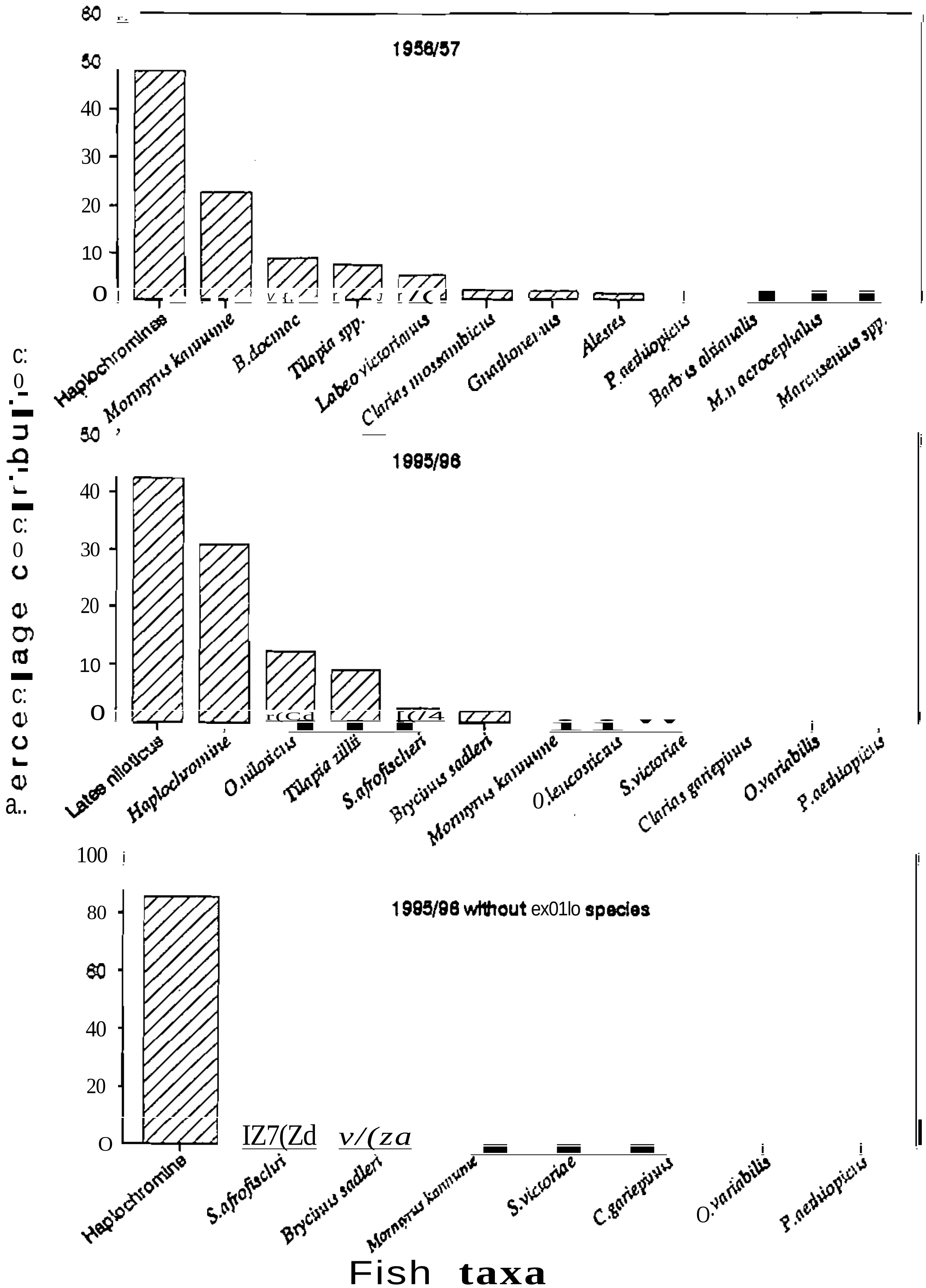


Fig. 19. Comparison of current relative abundance of fish taxa with the pre - perch data

variabi/is and 0. *escu/entus*. Haplochromines and *Mkannume* were caught at every station while *L. victorianus* and C. *mossambicus* occured at a few stations.

In the present study, numbers of haplochromines, 0. *ni/oticus,* 0. *variabilis,* 0. */eucosticus,* 0. *escu/entus, T zillii, B. jacksoni,* C. *gariepinus,* and *P. aethiopicus* were most abundant in the inshore fleet decreasing ourwards towards the open water whereas that of *L. niloticus,* and *Synodontis spp,* were highest in the 200m offshore fleet decreasing towards the shoreline. Fish species diversity decreased with increasing distance from the shoreline, which at all the sites sampled, was fringed with aquatic macrophytes. Rwamafuta and Kikondo sites, both of which are characterised by rocky shorelines, had a high species diversity also in the middle fleets. Among the haplochromine cichlids, most species were most abundant in the 0 m position decreasing outwards into the 200 m position except A. "unicuspids" which increased from 0 m position to the 200 m position. Some species showed preference for particular habitats. Among such species were *N nigricans,* and *N. pseudonigricans* which occured mostly at Rwamafuta and Kikondo both stations of which have rocky habitats. *P. "yellowbody"* was recorded only from Rwamafuta. *Astatoti/apia* sp. *P. "sharp teeth"* and *P. head"* occured only at Kiryowa. The rest of the species were recorded from several stations but in varying

Studies out before the introduction of Nile perch, showed that the majority of Lake Victoria fishes lived in shallow inshore waters and that species had definite habitat prefernces so that their relative abundance differed according to the habitat type (Beauchamp, 1956). Greenwood (1974) noted that representatives of all trophic catagories could occur in several habitats although the algal grazers and the species feeding on higher plants were restricted to habitats or parts of habitats where there are rooted plants or, in the case of the grazers (e.g *N nigricans),* suitable substrata for algal growth. It was also noted that some species may move berween habitats, or from one type of substrate to another. In Lake Victoria it seems probable that some species will at times utilise this ability to shift habitats at least as a measure to avoid adverse conditions (Fryer & Iles, 1972). In the 1989-1992 survey it was also found that marginal swamps and rocky reefs were important refugia for indigenous·species in Lake Victoria (Kaufman & Ochumba, 1993). It was noted in the Mwanza· Gulf of Lake Victoria (Witte *et a/.,* in a few habitats within lake the original communities of fish species seem less affected, e.g the rock-dwelling haplochromines. Ogutu-Ohwayo (1993) noted that many surviving species, especially haplochromines, in Lake Nabugabo were confined to macrophytes along the lake margin.

Inshore areas with aquatic macrophytes may serve as both structural and in some cases low-oxygen refugia for prey species from Nile perch. Nile perch is very sensitive to low-oxygen conditions which may limit their interaction with prey species in hypoxic habitats (Fish 1956). Schofield and Chapman (unpublished data) found several lines of evidence that Nile perch are relatively intolerant of low-oxygen conditions including high threshlolds for aquatic surface respiration relative to other indigenous fishes of the Lake Victoria basin, a faster time to loss of equilibrium in hypoxic conditions than other species from the region, and a high critical oxygen· tension. In addition, during fish kills on Lake Victoria, Nile perch exhibit higher mortality than many indigenous species. It was also observed during fish kills on Lake Victoria that Nile perch are more sensitive to low levels of dissolved oxygen, more so than many cichlids, thus prey species could exploit hypoxic habitats as refugia from Nile perch. Chapman et al (1995) demonstrated that some of the cichlids from Lake Victoria can tolerate extremely low levels of oxygen which may permit these fishes to use structural inshore habitats as refugia. In the present study dissolved oxygen levels, at all the sites, were lowest along shoreline increasing outwards into the open water.

Recent studies had indicated that haplochromine cichlids and other native species had been depleted from Lake Victoria. This study has shown that some native species have survived in the nearshore areas of the lake especialy areas with macrophytes. Ogutu-Ohwayo (1994) has reported resurgence, of native species, especially haplochromines in Lake Kyoga following reduction of Nile perch stocks due to overfishing and enhancement of macrophyte refugia due to the spread of hyacinth. Similar changes may take place in Lake Victoria especially as Nile .perch is subjected to heavy fishing pressure due to the ready market provided by the fish processing

Conclusion and Recommendations

Comparison of the fish catches recorded before introduction of Nile perch with those after its introduction and establishment indicates that relative abundance of various fish taxa **in** Lake Victoria has changed. A fishery once dominated by cichlids (tilapiines and haplochromines) is now dominated by the introduced predator, *Lates niloticus,* and some native species have either disappeared or are extinct. The number ofhaplochromine species has also reduced.

The results also indicate that the distribution of the surviving native species in Lake Victoria has not changed from what it was before the introduction of exotic species into the lake. The surviving native species occur mostly in inshore areas with macrophyte cover and in areas with rocky habitats. Their persistence with Nile perch may relate to their use of structural inshore areas which may serve as refugia for prey species from Nile perch.

In view of the above observations, protection of macrophyte refugia and rocky outcrops would be valuable in conservation of endangered fish species in Lake Victoria.

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